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CHILLING REQUIREMENTS FOR BREAKING DORMANCY OF WESTERN WHITE PINE SEEDLINGS

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ABSTRACT

*One- and 2-year-old western white pine (*Pinus monticola *Dougl.) seedlings representative of five full-sib families were artificially chilled at 40° F. from 0 to 14 and from 8 to 20 weeks, respectively. After chilling, the seedlings were placed in a growth chamber and exposed to a 16-hour photoperiod and a 70°-50° F. temperature regime. Chilling for at least 14 weeks was necessary for seedlings to approach maximal shoot elongation.*

Most temperate zone woody plants have a period of winter dormancy. Such plants must be subjected to cool temperatures for extended periods before they can be released from dormancy and begin normal growth the following spring. Although most of the early work on dormancy release was done on fruit trees (see Samish 1954; Romberger 1963; or Vegis 1964, for general reviews), a number of recent papers have reported chilling requirements for forest trees.

Nienstaedt (1966, 1967) examined the chilling requirements of seven species of spruce and found that all required 6 to 8 weeks at 40° F. to break dormancy promptly when returned to growing conditions. In other work, Dormling and others (1968) found that an optimum growth cycle could be maintained for Norway spruce (*Picea abies* (L.) Karst.) by means of a 4-week chilling period. Berry (1965) reported that eastern white pine (*Pinus strobus* L.) required 8 weeks of chilling for "normal" growth.

Examples of the chilling requirements of deciduous forest trees are sweetgum (*Liquidambar styraciflua* L.), 7 to 9 weeks (Farmer 1968); and red maple (*Acer rubrum* L.), 4 weeks (Perry and Wang 1960). Kriebel and Wang (1962) reported that 13 weeks were needed to achieve most rapid bud-break in sugar maple (*Acer saccharum* Marsh.). Perry and Wang (1960), Kriebel and Wang (1962), and Nienstaedt (1967) found that seedlings of

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the same species from different provenances had different chilling requirements. They reported that seedlings from milder climates usually required less chilling than did those from colder climates. Perry and Wang (1960) also detected differences in chilling requirements among the progenies of individual mother trees from a single area.

On trees that have not had sufficient chilling for terminal buds to develop normally, lateral buds often grow and cause misshapen trees (Holst 1962; Perry and Wang 1960). Conversely, Perry and Wang also found that excess chilling delayed the start of growth for a number of red maple progenies.

The study reported here determined the period of artificial chilling needed by western white pine (*Pinus monticola* Dougl.) seedlings to break dormancy and to produce "normal" growth. The information will be of value when seedlings are to be grown in a greenhouse or a growth chamber.

MATERIALS AND METHODS

Seed from five crosses among 10 trees at elevations ranging from 2,700 to 3,500 ft. were stratified for 100 days and sown during April 1968, in 1-1/2-inch "Jiffy" peat pots containing equal parts of forest soil, sand, and peat moss. When sufficient seed had germinated, the 3- to 4-week-old seedlings and their pots were placed in 8-inch-deep wooden flats containing the same soil mixture. Eight seedlings from each of the five families were randomly planted in each of 17 flats. The flats were then placed in a lathhouse until the seedlings had completed their normal first-year growth cycle.

Artificial chilling was begun in mid-September when all seedlings had set their first-year buds; plants were chilled in a cold room at 40±2° F. Fluorescent lights were operated to provide 500 ft.-c. of light for 8 hours each day. Nine flats of seedlings were subjected to various chilling treatments the first year: One received no chilling, seven were chilled for periods ranging from 2 to 14 weeks by 2-week increments, and the last, the control, was held in the lathhouse to receive "natural chilling" for 18 weeks. The other eight flats were kept in the lathhouse until the end of the second summer.

Following the prescribed chilling period, the flats were moved to a growth chamber set to provide a 16-hour "day," a light intensity of 3,000 ft.-c., and a temperature of 70° F. followed by an 8-hour "night" at 50° F. The height of each seedling was measured when the flats were transferred to the growth chamber and at 1-week intervals thereafter for 13 weeks. At the end of that time, the seedlings had grown and again set buds. An analysis of variance was calculated for the total epicotyl growth. Differences between treatment means were compared by the method presented by Snedecor (1956, page 253).

In order to determine the chilling requirements of 2-year-old seedlings and to compare the results with those for 1-year old seedlings, we left the remaining eight flats in the lathhouse through the winter and the second summer. However, because of the first-year results, we eliminated the shortest chilling periods and added some longer ones. The resulting chilling periods for the 2-year-old seedlings were as follows: 8, 10, 12, 14, 16, 18, and 20 weeks. We left the eighth flat, the control, in the lathhouse for 22 weeks of natural chilling. Cold room and growth chamber conditions were the same as for the 1-year material and the same measurement schedule was followed.

We expanded our statistical analysis of second-year data to evaluate family differences and family X treatment interaction effects, in addition to comparing treatment means.

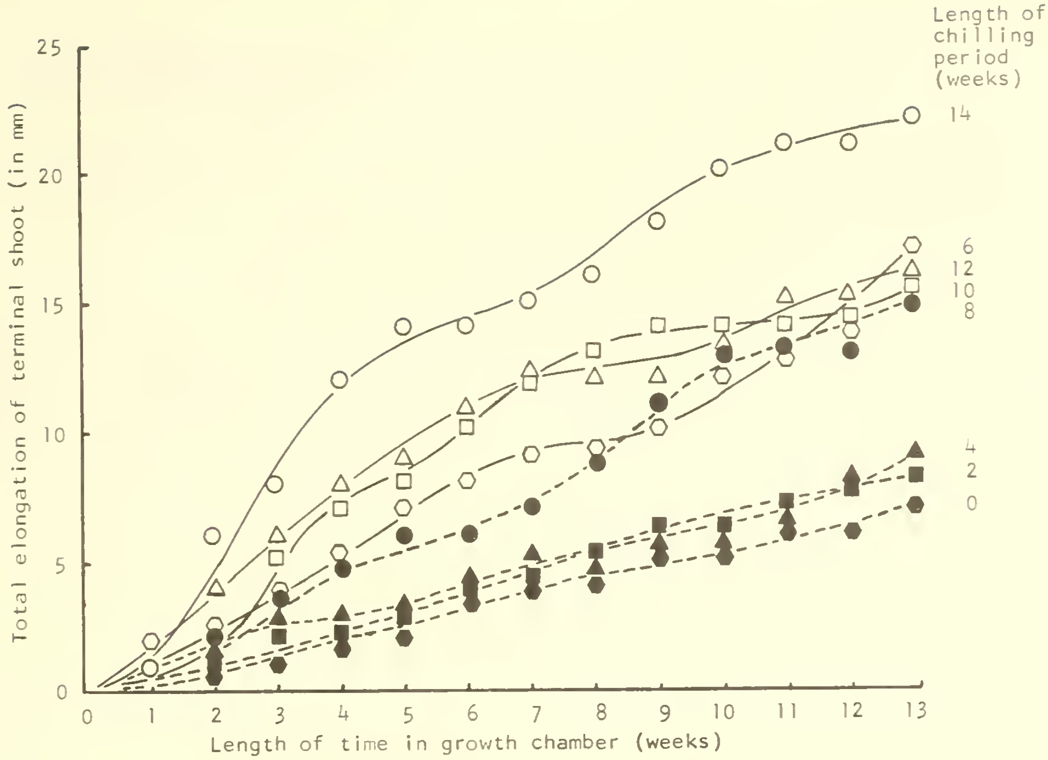

Figure 1.--Terminal elongation of 1-year-old western white pine seedlings chilled for various periods of time. (All curves are hand drawn.)

RESULTS AND DISCUSSION

One-year-old seedlings.--Seedlings given progressively longer periods of chilling grew at progressively faster rates and made more total epicotyl growth than those that received less chilling (fig. 1). Most seedlings continued to make some height growth throughout the 13 weeks they were in the growth chamber.

Total epicotyl length of seedlings chilled for 14 weeks was significantly[2] greater than those of all seedlings chilled for shorter periods. Differences among seedlings chilled for 6, 8, 10, or 12 weeks were not significant, but all seedlings given those treatments grew significantly more than those chilled for 0, 2, or 4 weeks. The 0-, 2-, and 4-week treatments did not differ significantly. The box of seedlings left in the lathhouse to serve as a control was frozen solid during unusually cold weather. Shortly after we brought these control seedlings indoors to start their growth period, most showed evidence of damage or were dead. Consequently, we had no control for effective comparison. Because each additional 2 weeks of chilling resulted in additional growth of the seedlings, the minimum chilling needed to achieve optimum growth might not have been reached. However, the total growth of the seedlings chilled for 14 weeks approximated that of seedlings in our nursery operations.

Trauma-induced simple leaves developed and lateral buds often elongated abnormally on seedlings chilled for very short periods. When this occurred, bushy, misshapen seedlings resulted. Exposure of the seedlings to shorter or longer photoperiods in the growth chamber might have resulted in quite different growth patterns. The 16-hour

[2]All significance tests were made at the 5-percent probability level.

photoperiod we chose might have had some long-day promotional effects, particularly on seedlings chilled for short periods, but it was chosen to approximate the natural photoperiod at the time trees in the field resume growth in the spring.

Two-year-old seedlings.--The pattern of shoot elongation for the 2-year-old seedlings (fig. 2) was much different than for 1-year-old seedlings. Whereas almost all 1-year-old seedlings grew at an almost constant rate for 13 weeks, the 2-year-old ones completed most of their growth in a 4- to 8-week period, depending on the chilling treatment.

Differences in the first and second year shoot-elongation patterns might indicate that artificial chilling was begun too early the first year (mid-September) to allow sufficient time for bud maturation. During the year the seeds germinate, western white pine seedlings grown in a nursery commonly do not complete growth until early September. In contrast, growth during the second year is usually confined to a 5- to 6-week period that ends in early June. Dormling and others (1968) found that a 4-week bud-maturation period prior to chilling was required in an optimal cycle for Norway spruce.

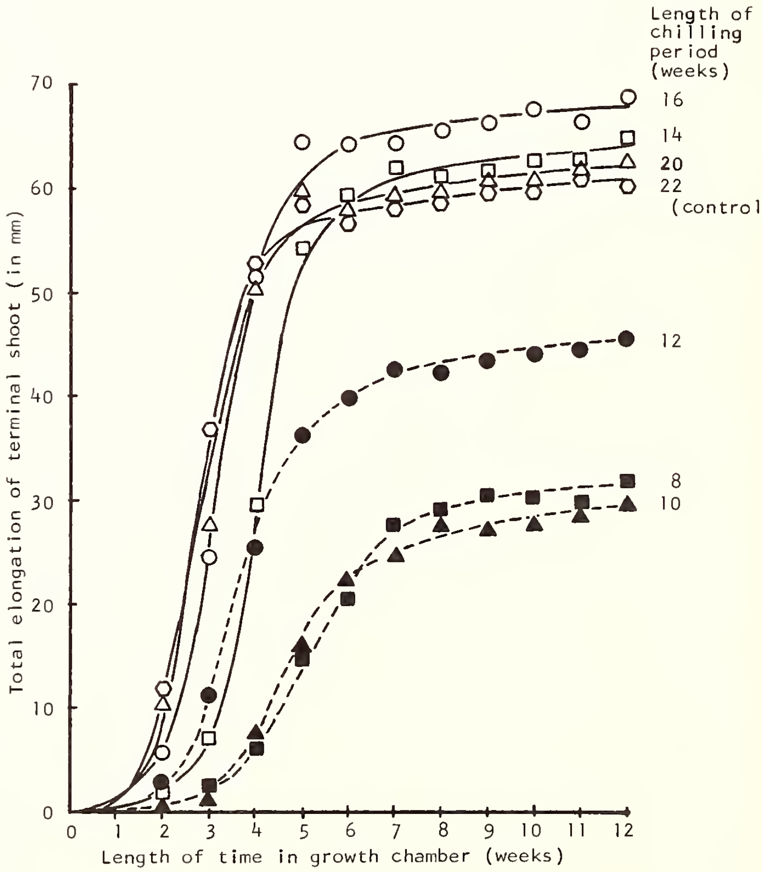

Figure 2.--Terminal elongation of 2-year-old western white pine seedlings chilled for various periods of time.

Seedlings chilled 16 or more weeks had begun growth by the end of the second week in the growth chamber and had completed 95 percent of their total shoot elongation by the end of the fifth week. Growth in seedlings chilled 12 or 14 weeks did not begin until the third week, but then continued until the seventh week. Seedlings chilled 8 or 10 weeks did not grow much until the fourth week, but continued to grow until the eighth or ninth week.

Total new epicotyl growth did not differ significantly among seedlings that had received 14, 16, 20, or 22 (lathhouse control) weeks of chilling, but the growth of all differed significantly from that of seedlings chilled for 8, 10, or 12 weeks. Seedlings chilled for 12 weeks grew significantly more than those chilled for 8 or 10 weeks, but the latter two did not differ significantly. A fungal growth developed on the box of seedlings chilled for 18 weeks and the seedlings were severely damaged; they were eliminated from the test.

Further statistical analysis of the data showed that the final total height of individual families differed, but the family X treatment interaction was not significant. Apparently, all families tested had essentially the same chilling requirements.

The trend of seedlings chilled for more than 16 weeks to make more rapid initial growth (but slightly less total growth) was significant, but (as mentioned earlier) the total growth for the 14-, 16-, 20-, and 22-week treatments did not differ significantly.

CONCLUSIONS

Both 1-year-old and 2-year-old western white pine seedlings appear to require a minimum of 14 weeks of artificial chilling at 40° F. (16 weeks probably are near optimum) to obtain maximum "normal" growth. Additional chilling will promote faster initial growth, but might result in less total growth. Under the growth chamber conditions we used, most seedlings made some growth, but those chilled for less than 14 weeks did not reach their growth potential.

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